

National Aeronautics and Space Administration



Project Status Report

High End Computing Capability Strategic Capabilities Assets Program

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HECC Supports High-Resolution Simulation of Rotorcraft Wakes



- Researcher Neal Chaderjian, NASA Advanced Supercomputing (NAS) Division at Ames, is developing improved, high-fidelity computational fluid dynamics (CFD) tools to help engineers reduce noise pollution and increase performance for rotorcraft designs.
- Using the OVERFLOW 2.2 CFD code, advancements include: (a) Improved rotor wake resolution using high-order spatial accuracy, automated grid adaption, and detached eddy simulation; (b) prediction of Figure of Merit (a measure of thrust and torque) to within 0.1% of measured values; (c) reduction of vortex diameter error from 700% to 25% one revolution from the rotor tip.
- HECC supercomputers enable verification and validation of new aeromechanics computational tools, which is not possible on smaller systems; typical rotorcraft solutions require 35M-700M grid points, 256-4096 cores, and 1-3 weeks of continuous computation. Chaderjian has used 5 million SBUs in the last 4 months alone.
- Support from HECC experts who provide concurrent time-dependent flow visualization has been crucial in understanding the very complex nature of rotor wakes.

Mission Impact: This work, enabled by HECC resources, supports NASA ARMD's Subsonic Rotary Wing Project objective to develop improved physics-based computational tools to better predict and understand rotorcraft aeromechanics phenomenon.

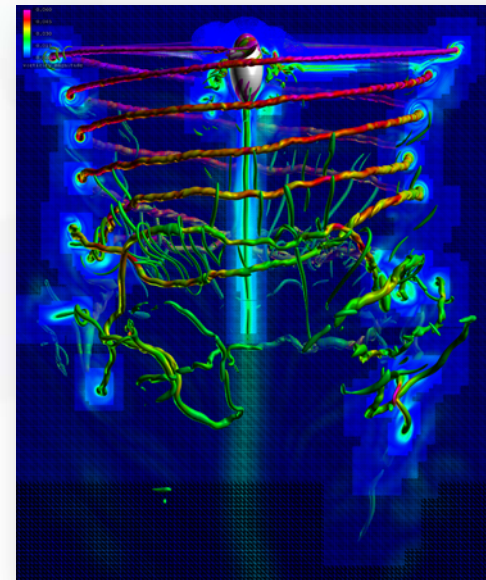


Figure: Simulation of an isolated V-22 Osprey rotor in hover. Two levels of grid adaption improve rotor vortex resolution and predict the Figure of Merit within experimental accuracy. Magenta is high vorticity and blue is low vorticity.

POC: Neal Chaderjian, neal.chaderjian@nasa.gov, (650) 604-4472, NASA Advanced Supercomputing Division



HECC Resources Used for Modeling and Simulation of Solar Magnetodynamics

- Through a Science Mission Directorate grant, physicists at Michigan State University are running massive calculations on the Pleiades supercomputer to help understand the behavior of magnetic fields near the Sun's surface, which affects space weather.
- Realistic numerical simulations of solar surface magneto-convection are needed to model the Sun's atmospheric and subsurface behaviors, interpret observational data, and test and validate observational analysis and inversion procedures.
- Dr. Robert Stein's results compare observables calculated from the simulations with observations from global satellites and telescopes to verify the simulation results and observational analysis procedures.
- Massively parallel supercomputers are essential for running these calculations; Stein's calculations were performed using up to 2,016 cores on Pleiades.
- In addition, HECC visualization experts provide images and movies that show never-before-seen features in the data; this is especially important in following the emergence of magnetic flux and its evolution in time.

Mission Impact: HECC supercomputing resources are helping NASA understand how people, technological systems, and the habitability of planets are affected by solar variability and magnetic fields.

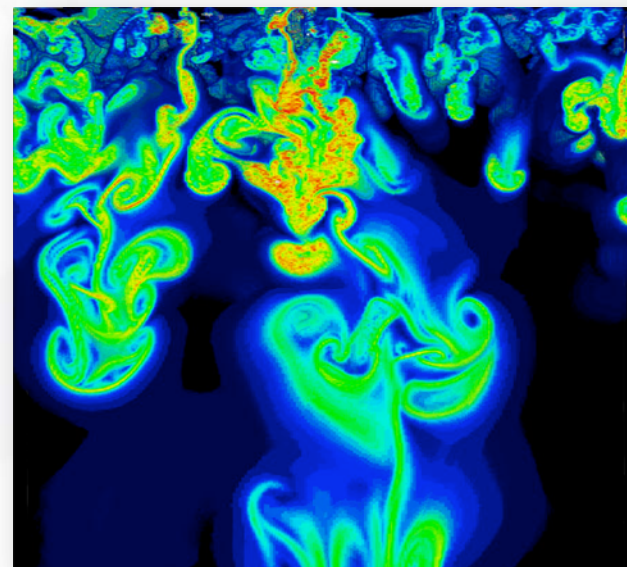


Figure: The solar convection zone is very turbulent. This image shows vorticity visualized by the Finite Time Lyapunov Exponent Field for a time interval of 11.75 hours, in a subdomain 21 megameters (Mm) wide by 19 Mm high by 0.5 Mm thick, from a 48-by-48 Mm wide by 20 Mm deep simulation.

POC: Robert Stein, stein@pa.msu.edu, (517) 884-5613,
Michigan State University



HECC Resources Enable Fast-Turnaround Simulations of Candidate SLS Architectures

- NAS modeling and simulation (M&S) experts have performed several comprehensive aerodynamic simulations of candidate space launch system (SLS) vehicle designs.
- The team modeled two vehicle designs being developed by the SLS Resource Allocation Committee (RAC) Team 1, and one design being developed by the SLS RAC Team 2.
- Using Cart3D and OVERFLOW codes, a total of about 850 cases were simulated for the three vehicles, providing aerodynamic data covering a full range of flight conditions throughout launch.
- A new code, CINS-LAVA, was also used to simulate the SLS Team 2 vehicle over a high-resolution trajectory with 10 times more Mach numbers than typical aerodynamic analyses.
- HECC resources enabled these extensive analyses to be completed within very short turnaround times, enabling the SLS teams to meet deadlines for a key RAC review comparing alternate/candidate SLS architectures.

Mission Impact: These simulations are being used to assess and compare aerodynamic performance and structural loads for the candidate vehicles, and will contribute to the selection of an SLS architecture.

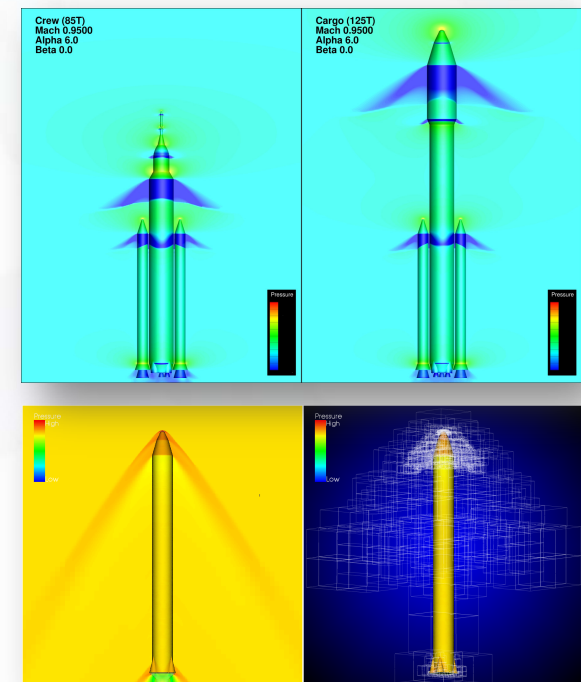


Figure: Visualizations of aerodynamic flows and surface pressures from CFD simulations of candidate space launch system (SLS) architectures.

POC: Cetin Kiris, Cetin.C.Kirisi@nasa.gov, (650) 604-4485,
NASA Advanced Supercomputing Division



Pleiades Delivers Over 1 Billion SBUs Since Installation in August 2008

- Since its installation in August 2008, the Pleiades supercomputer, operated by the HECC Project, has provided over 1 billion Standard Billing Units (SBUs) to NASA scientists and engineers.
- The number of SBUs this SGI ICE system has delivered in 2.5 years is more than double what Columbia, RTJones, and Schirra together delivered over their lifetimes.
- In November 2008, Pleiades debuted on the TOP500 list as the third-fastest computer in the world; since then, it has been expanded to 2.5 its initial size and now has 91,136 Intel Xeon processor cores that together can perform over 10^{15} floating point operations per second.
- Used by more than 1,000 NASA scientists and engineers to support state-of-the-art investigations for all NASA mission directorates, Pleiades will expand in 2011 to support the Agency's continually increasing computing needs.

Mission Impact: Increasing system capacity provides NASA Mission Directorates with the computational resources to support the research, science, and engineering tasks needed to accomplish their goals and objectives.

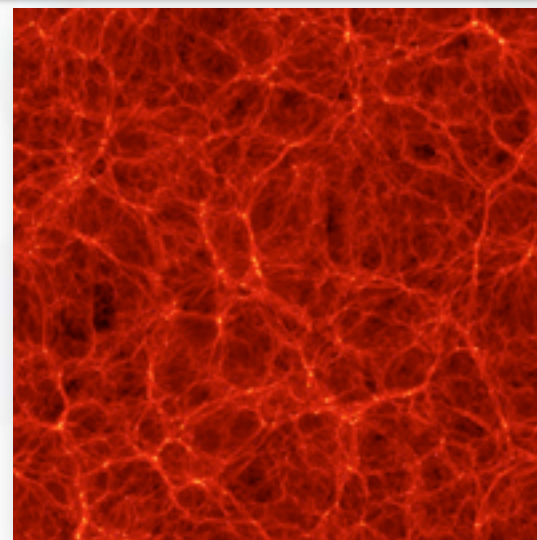
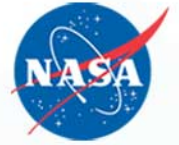


Figure: Image from the “Bolshoi” simulation, which models the gravity-driven distribution of dark matter in a 1-billion light year cube with 8.5 billion particles. The code ran on Pleiades for 18 days, consumed six million processor-hours, and generated 200 terabytes of data.

POC: Catherine Schulbach, Catherine.H.Schulbach@nasa.gov, (650) 604-3180, NASA Advanced Supercomputing Division

Pleiades Updates Improve System Reliability and Enhance Performance



- In February, the Pleiades supercomputer operated in “dedicated mode” for a five-day period in order to complete previously deferred maintenance and implement improvements to the system.
- System enhancements were focused on: (a) increasing the metadata performance of the nobackupp10 Lustre filesystem; (b) testing improvements to the InfiniBand network interconnect; (c) expanding the Network File System (NFS) home filesystem storage by a factor of 2.7X; and (d) providing a 60-terabyte scratch filesystem for workloads better suited to the NFS.
- System maintenance activities included replacing defective hardware, running filesystem integrity checks, and updating firmware and software that had been deferred to minimize impact on HECC users.

Mission Impact: Improvements to system reliability and performance provide NASA users with a more usable computational capability.



Figure: Dedicated time on the Pleiades supercomputer (above) enabled essential changes to improve ongoing system operations.

POC: Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408,
NASA Advanced Supercomputing Division



New Power Distribution Units Installed to Support Additional Computer Racks

- The HECC Facilities team has installed 8 new power distribution units (PDUs) to prepare for future Pleiades expansions; installation of these PDUs permitted the move of 8 original PDUs, making way for new construction.
- The newly cleared computer floor area will be the site for up to 32 new Pleiades racks; this area is also being outfitted with chilled water supply and return lines for the new racks.
- The 8 removed PDUs will be reused to power future systems.
- Conversion to the new PDUs was timed to coincide with a recent scheduled systems dedicated time (see slide # 7).
- The “replug” to the new PDUs and their 64 electrical outlets required 3 hours during the dedicated time, and avoided additional interruption to production computing work.

Mission Impact: The installation of new power distribution units makes way for the HECC facility to provide additional computing capability to the NASA user community, which will increase the resources available to accomplish Agency science and engineering goals.



Figure: Four of the 8 power distribution units (PDUs) installed during the recent HECC facility work. The 8 PDUs are now powering 32 of Pleiades' 154 racks.

POC: John Parks, john.w.parks@nasa.gov, (650) 604-6006,
NASA Advanced Supercomputing Division



Security Team Deploys Advanced System Mining Across the Enterprise

- The HECC Security team has deployed its in-house-developed system mining software across the Pleiades supercomputer and other Linux and Macintosh systems.
- The advanced miner captures detailed information about running processes, including owner, executable path and port(s), which supplements the package information provided by the regular miner software.
- The advanced miner also gives HECC the capability to automatically perform more detailed security checks before new systems are put into production, which ultimately results in a higher level of confidence that the systems are properly secured.
- Once the Security team has established what ports, processes, and software are normally running on HECC systems, they can create algorithms to automatically identify deviations and then notify the team for further investigation.

Mission Impact: Having a more detailed understanding of the security settings installed and running on NASA supercomputers and systems allows security experts to establish normal system baselines and detect deviations.

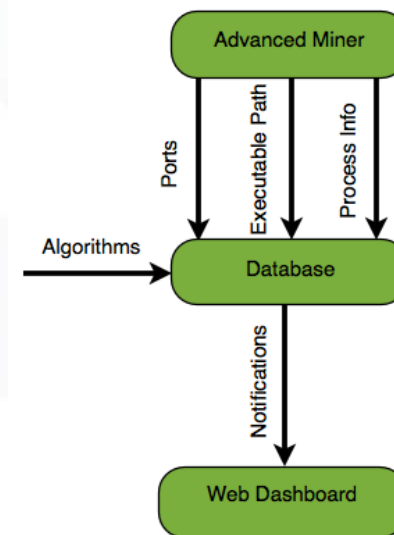


Figure: The HECC miner runs on each system, and securely sends information to a database. The Security team routinely runs its algorithms against all the data and sends any notifications to a dashboard page on the team's web portal.

POC: Christopher Keller; christopher.keller@nasa.gov, (650) 604-5597, NASA Advanced Supercomputing Division, Computer Sciences Corp.



HECC Security Team Increases Passive Malware Detection

- Malware is a growing problem that affects countless computer systems, and is not always detected by anti-virus software and intrusion detection systems.
- To increase detection of potential malware infections, HECC's Security team has introduced a set of rules, filters, and dynamic lists to the Security Monitoring System designed to look for characteristics of potential malware infections. Enhancements include:
 - Suspicious IP address that may serve malware or may be part of a botnet are automatically imported into the Security Monitoring System.
 - Network traffic is monitored for traffic to and from suspected malware or botnet sites, and profiled for traffic patterns that may indicate a malware infection.
 - Multiple events are correlated to reduce the number of false-positive alerts.

Mission Impact: By increasing the malware detection in the Security Monitoring System, HECC's Security team is able to detect potential malware infections and help prevent further infection.

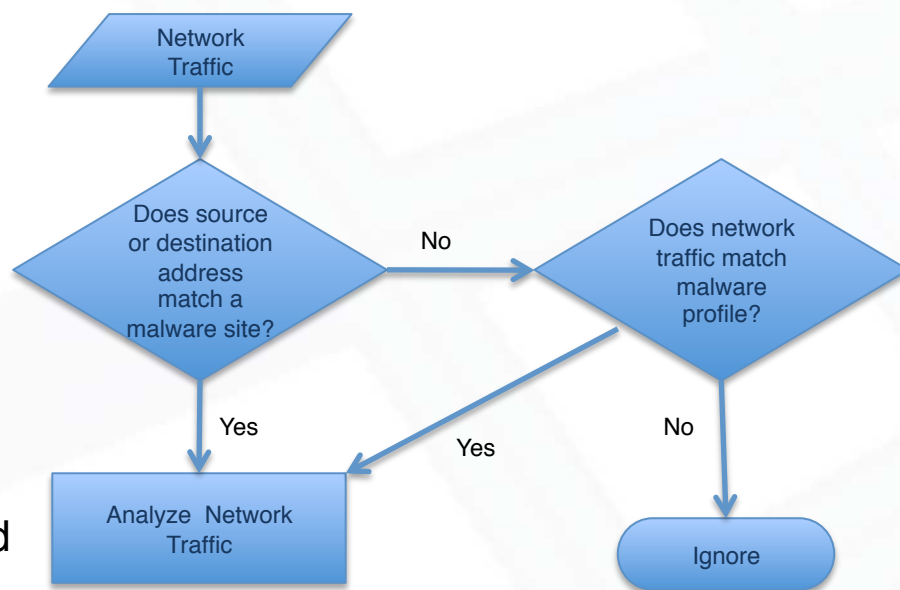


Figure: Basic diagram of network traffic being analyzed for potential malware.

POC: Derek G. Shaw, derek.g.shaw@nasa.gov, (650) 604-4229,
NASA Advanced Supercomputing Division,
Computer Sciences Corp.



Network Team Completes Core Router Transition and 10G Upgrade to Access Layer

- The HECC local area network team has successfully transitioned the network core routers to a new network infrastructure in the facility's main communications room.
- The Cisco IOS (internetwork operating system) was also upgraded on the routers, enabling use of high-density 10-gigabit (G) modules; as a result, the access layer backbone network now has a total bi-directional capacity of 40G, compared to 4G previously.
- New network cabinets with added depth, width, and lockable doors also allows better cable management and security.
- The work was completed on schedule and with minimal impact to HECC users and staff.
- Reorganization of the core routers and new network cabinets also makes room for future expansion to the production and lab equipment in the communications room.

Mission Impact: Relocation of core network routers to new cabinets allows improved cable management and security. IOS upgrade enable support of high-density 10G hardware and 5x bandwidth improvement to access layer.

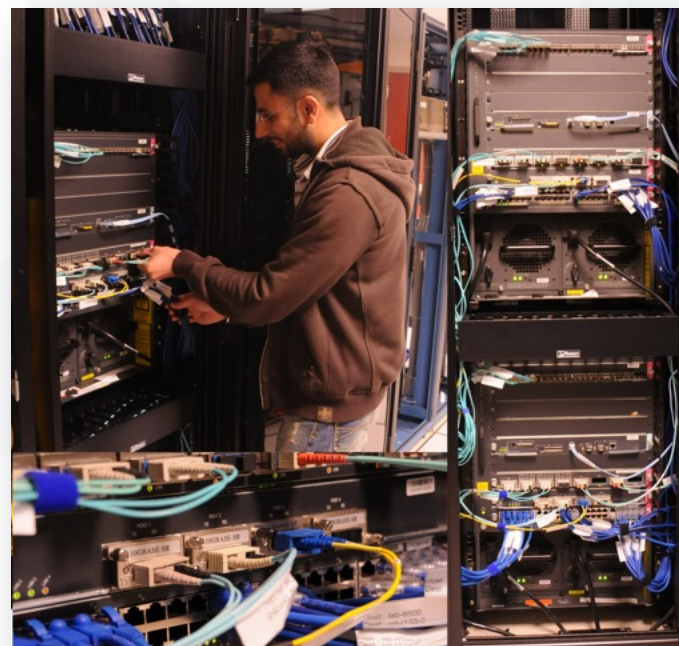


Figure: HECC network staff member Harjot Sidhu installs core routers in new cabinets.

POC: Christopher Buchanan, chris.buchanan@nasa.gov,
(650) 604-4308, NASA Advanced Supercomputing Division



Archive System Reaches Record-High Storage Usage

- Usage of the HECC archive system, which provides long-term data storage for NASA users, reached a new record high at the end of January 2011.
- The three combined archive systems (Lou 1-3) transferred a total of 4.5 petabytes of data to and from the SpectraLogic tape libraries.
- This is a factor of 3.3X increase compared to the average usage in 2010, and 18% higher than the previous high watermark reached in October 2010.
- Since the installation of Pleiades in August 2008, the computational capability has grown by 2.5X, but the yearly average archive usage has grown by 3.7X during the same period.

Mission Impact: As the HECC computational capability grows, the long-term storage must grow at a faster rate in order to support NASA users' demands for data storage.



Figure: HECC archive system usage has grown by 3.7x over a two- year period to keep pace with the expansion of the Pleiades system.

POC: Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408,
NASA Advanced Supercomputing Division



HECC Facility Hosts Several Visitors and Tours in February 2011

- HECC hosted 6 scheduled tour groups in February; guests received an overview of the HECC Project, demonstrations of the hyperwall-2 visualization system, and tours of the computer room floor. Groups included:
- The Astronaut Class of 2009—including 3 astronauts from the Japanese Space Agency (JAXA), 3 NASA Johnson staffers, and 10 Astronaut Candidates staff, as part of a larger visit to Ames Research Center.
- 15 Kepler team members and guests visiting Ames to attend the Kepler Mid-Mission Celebration event.
- Irish Consul General Gerry Staunton and Deputy Consul Barry O'Brien were given hyperwall demos and computer room tours.
- Congressmen Darryl Issa, Sang Yi, and Tom Alexander, joined by Center Director Pete Worden, received a computational fluid dynamics overview in the visualization lab.



Figure: HECC hosted the 2009 Astronaut Class on February 3, 2011; Visualization team member Tim Sandstrom demonstrated the hyperwall-2 system (above). Bill Thigpen and David Robertson gave the group a tour of the computer room.

*POC: Gina Morello, gina.f.morello@nasa.gov, (650) 604-4462,
NASA Advanced Supercomputing Division*



Presentations and Papers

Papers

- [A Programming Model Performance Study using the NAS Parallel Benchmarks](#), H. Shan, F. Blagojevi, S.-J. Min, P. Hargrove, H. Jin, K. Fuerlinger, A. Koniges, N.J. Wright. Journal of Scientific Programming, Vol. 18, No. 3-4 (2010) pp. 153-167.
- [Enabling Locality-Aware Computations in OpenMP](#), L. Huang, H. Jin, L. Yi, B. Chapman, Journal of Scientific Computing, Vol. 18, No. 3-4 (2010) pp. 169-181.
- [Emerging Flux Simulations and Proto-Active Regions](#), R. Stein et al, Astrophysics Journal, (submitted).*
- [CRASH: A Block-Adaptive-Mesh Code for Radiative Shock Hydrodynamics – Implementation and Verification](#), B. van der Holst¹ et al, The Astrophysics Journal, Volume 194, Number 2, 2011.*

Presentations

- “NASA Supercomputing and Its Impact on Agency Missions,” R. Biswas, Pennsylvania State University Cyberinfrastructure Day, February 1, 2011, State College, PA.
- Security team lead C. Keller presented the HECC Security Tools framework (Vulnerability Tracking System, ConsoleChecks, system data mining, etc.) at Ames Computer Security Officer meeting.

* HECC provided supercomputing resources and services in support of this work

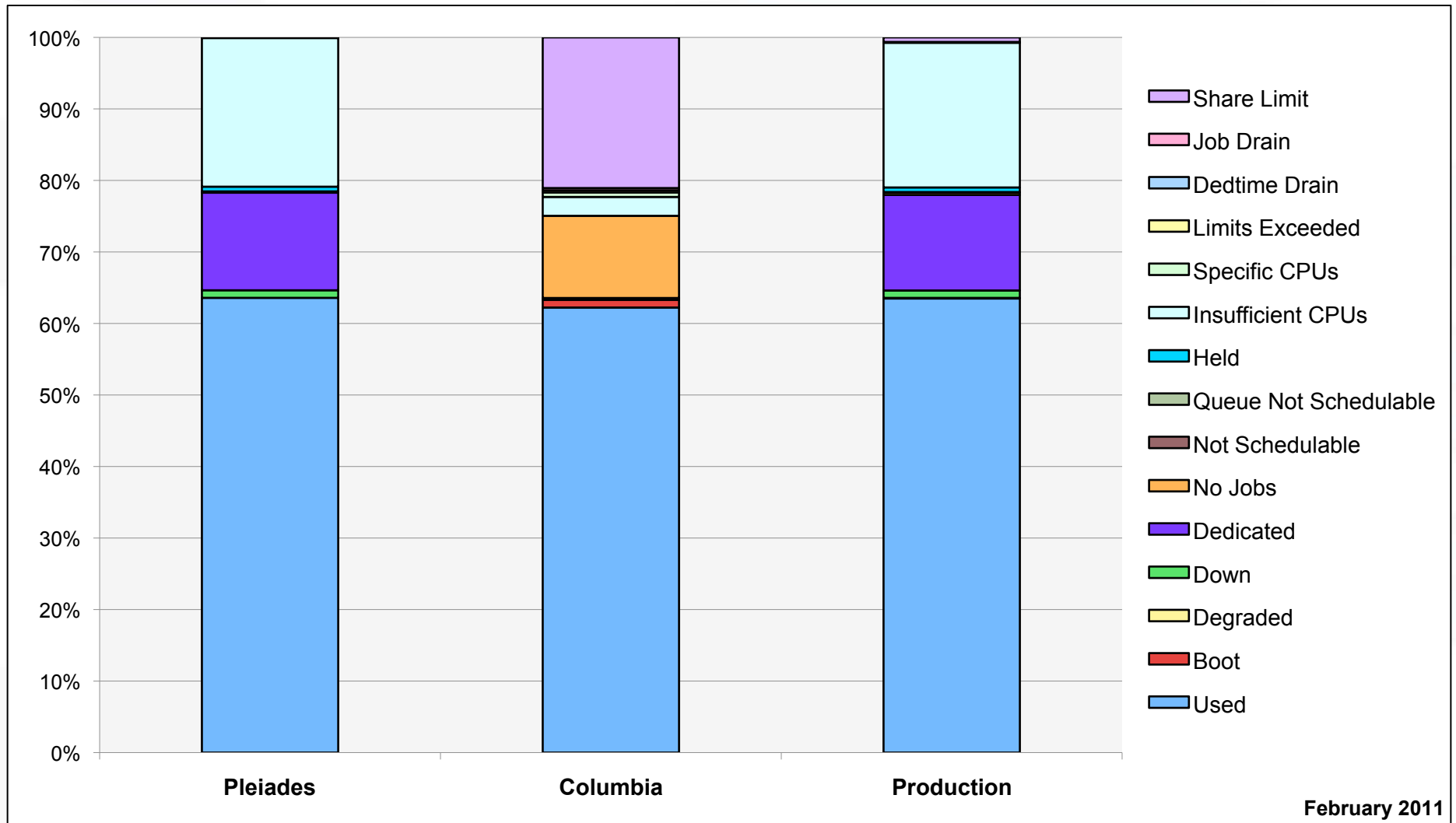
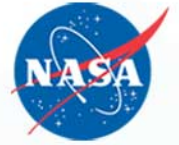
News and Events



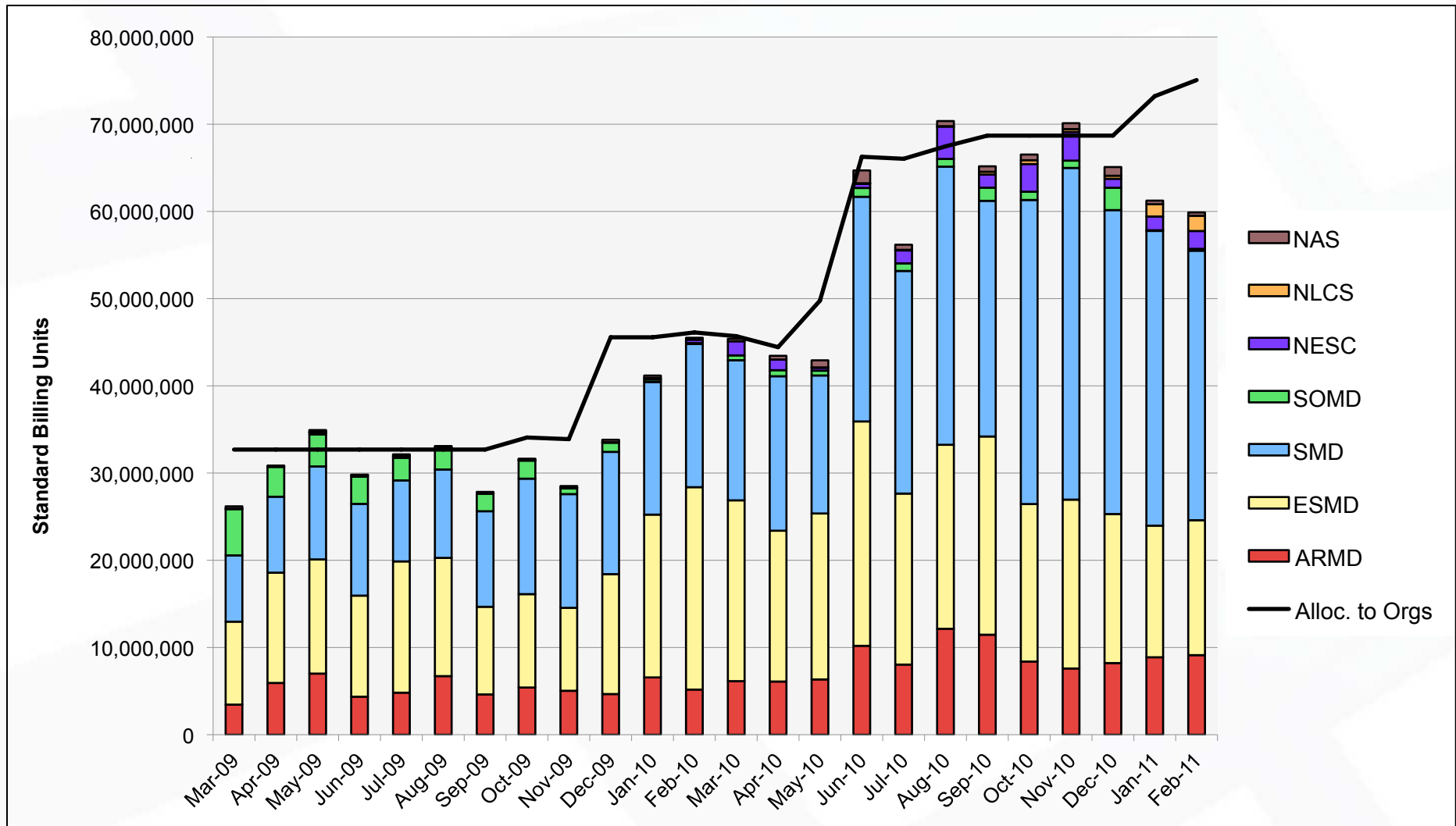
- [Watson's Ancestors: A Look at Supercomputers of the Past](#), *ComputerWorld*, February 1, 2011 – An article about IBM's Watson supercomputer taking on Jeopardy champs has a section on the Columbia supercomputer.
- [NASA Climate Funding Under Attack](#)
In an interview posted on KQED Public Media, NASA Ames Center Director Pete Worden noted that a lot of sophisticated climate modeling is done on the Pleiades supercomputer.
- [Computing supports discovery of Earth-like planets](#), *international science grid this week*, February 9, 2011 – Feature story discussing the computational challenges that the Kepler Mission faces and how the massive size of Pleiades allows timely processing not possible on their 512-core cluster.
- [Silent Symphony of the Cosmos](#), *Cosmos Online*, February 17, 2011 – Feature story on gravitational waves features an animation by HECC visualization expert Chris Henze.

* HECC provided supercomputing resources and services in support of this work.

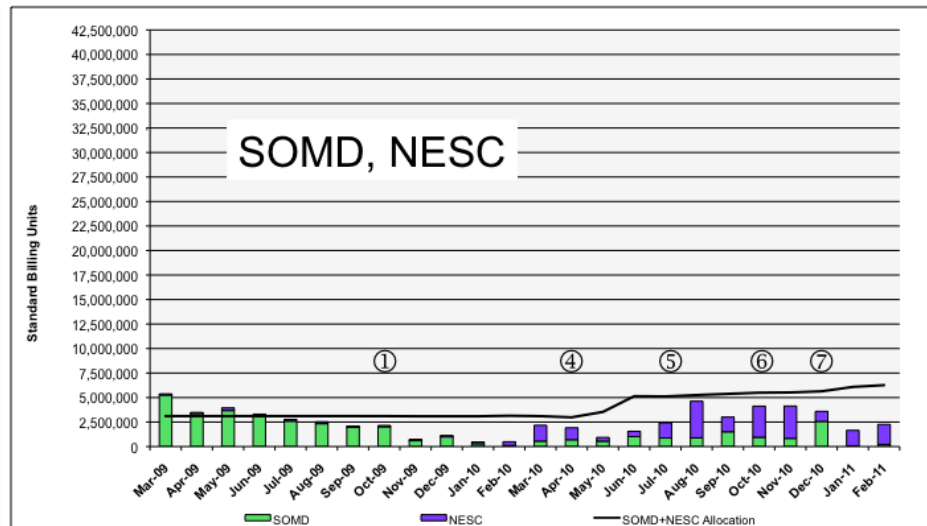
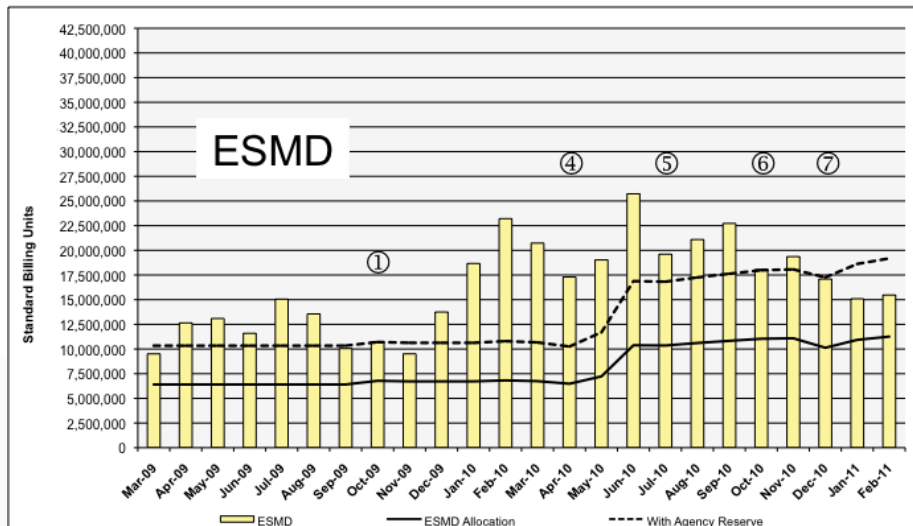
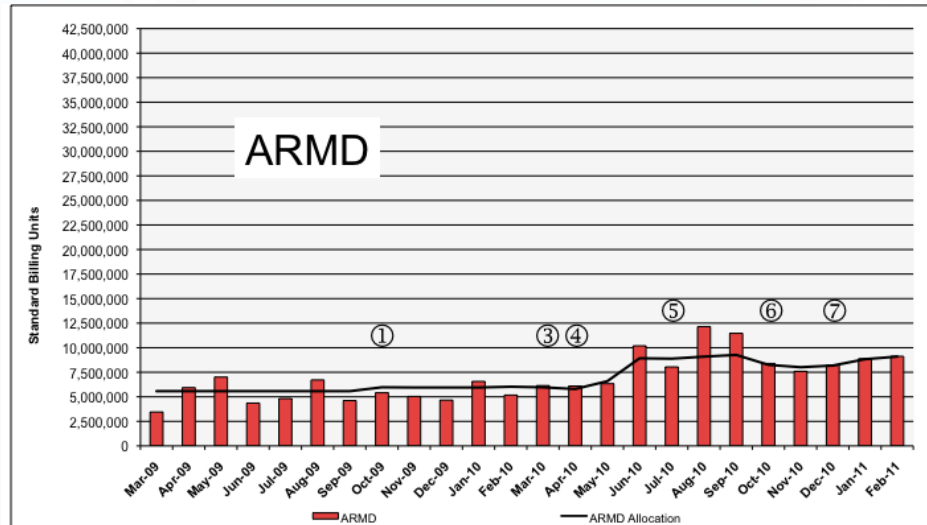
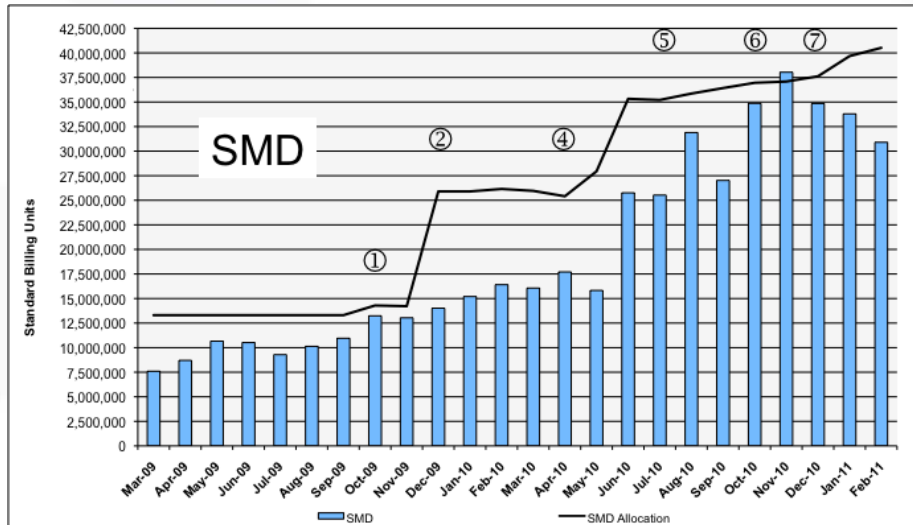
NAS Utilization



NAS Utilization Normalized to 30-Day Month

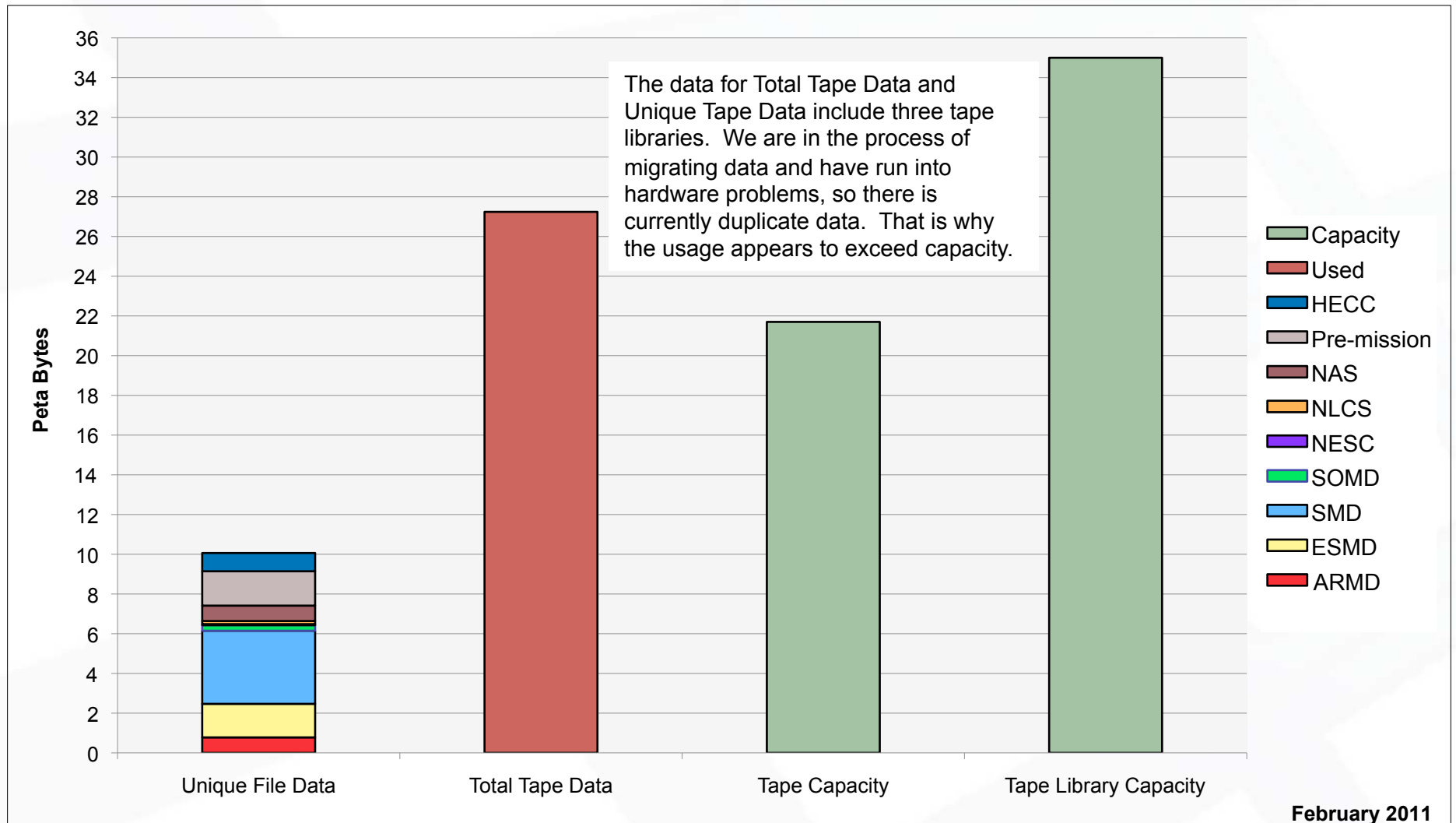
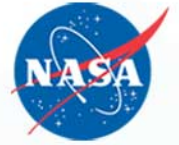


NAS Utilization Normalized to 30-Day Month

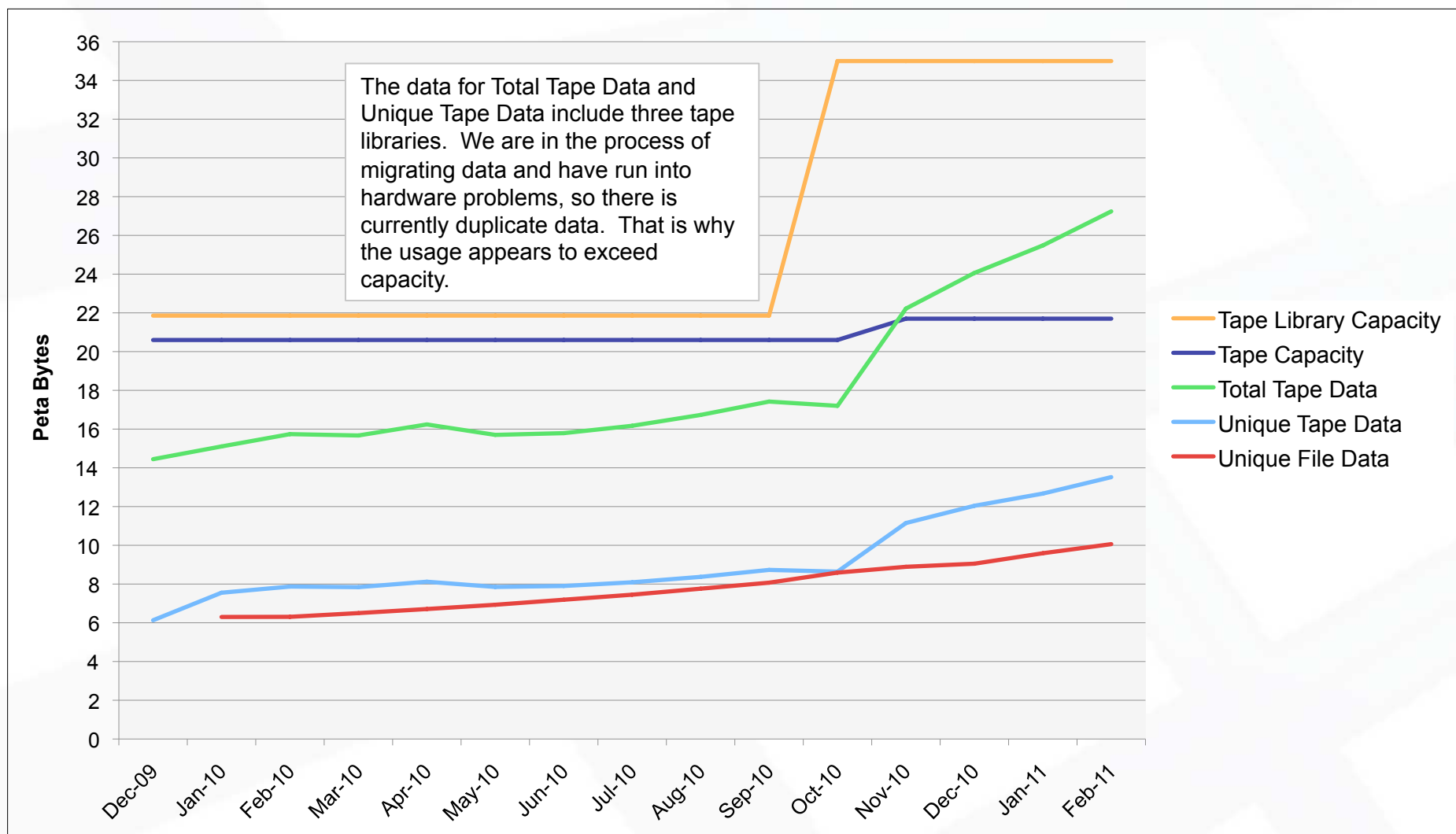
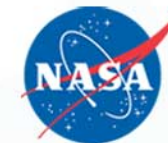


- ① Allocation to orgs. increased to 80% ② SMD augmentation ③ RTJones retired ④ 32 Westmere racks added
⑤ Schirra retired, 4 Westmere racks added ⑥ RTJones compensation removed ⑦ 8 Westmere racks added

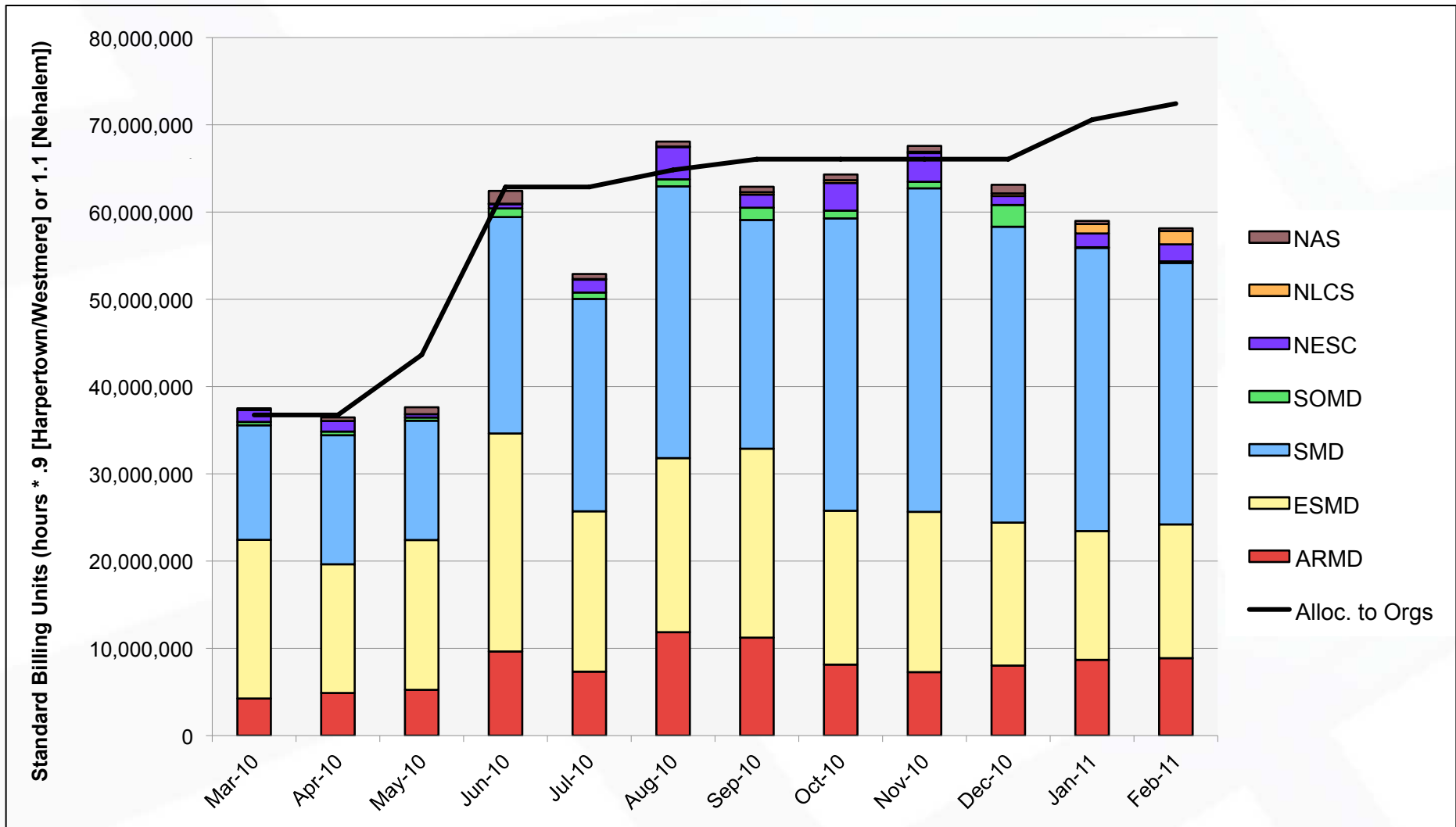
Tape Archive Status



Tape Archive Status

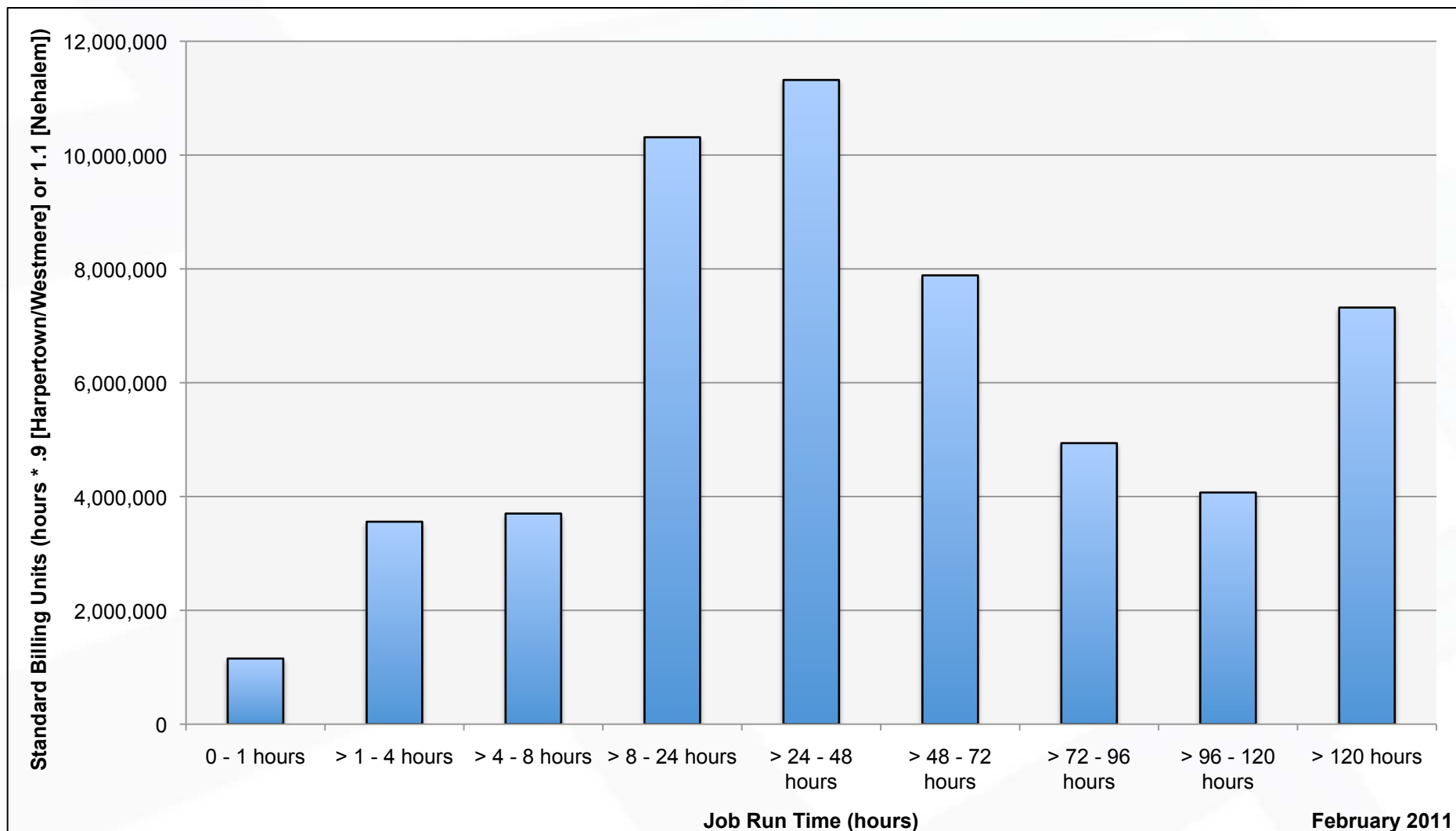


Pleiades: SBUs Reported, Normalized to 30-Day Month



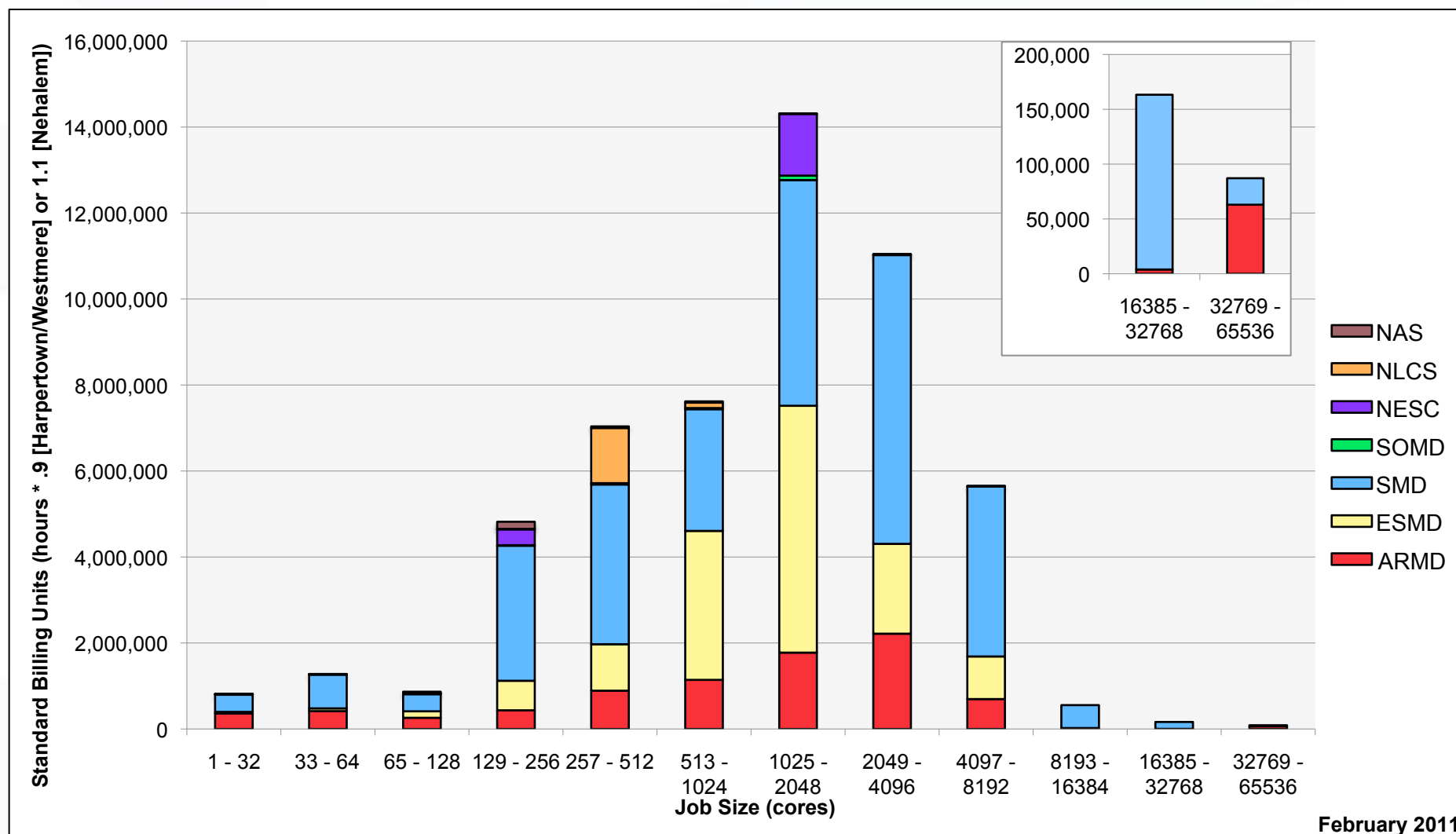


Pleiades: Monthly SBUs by Run Time



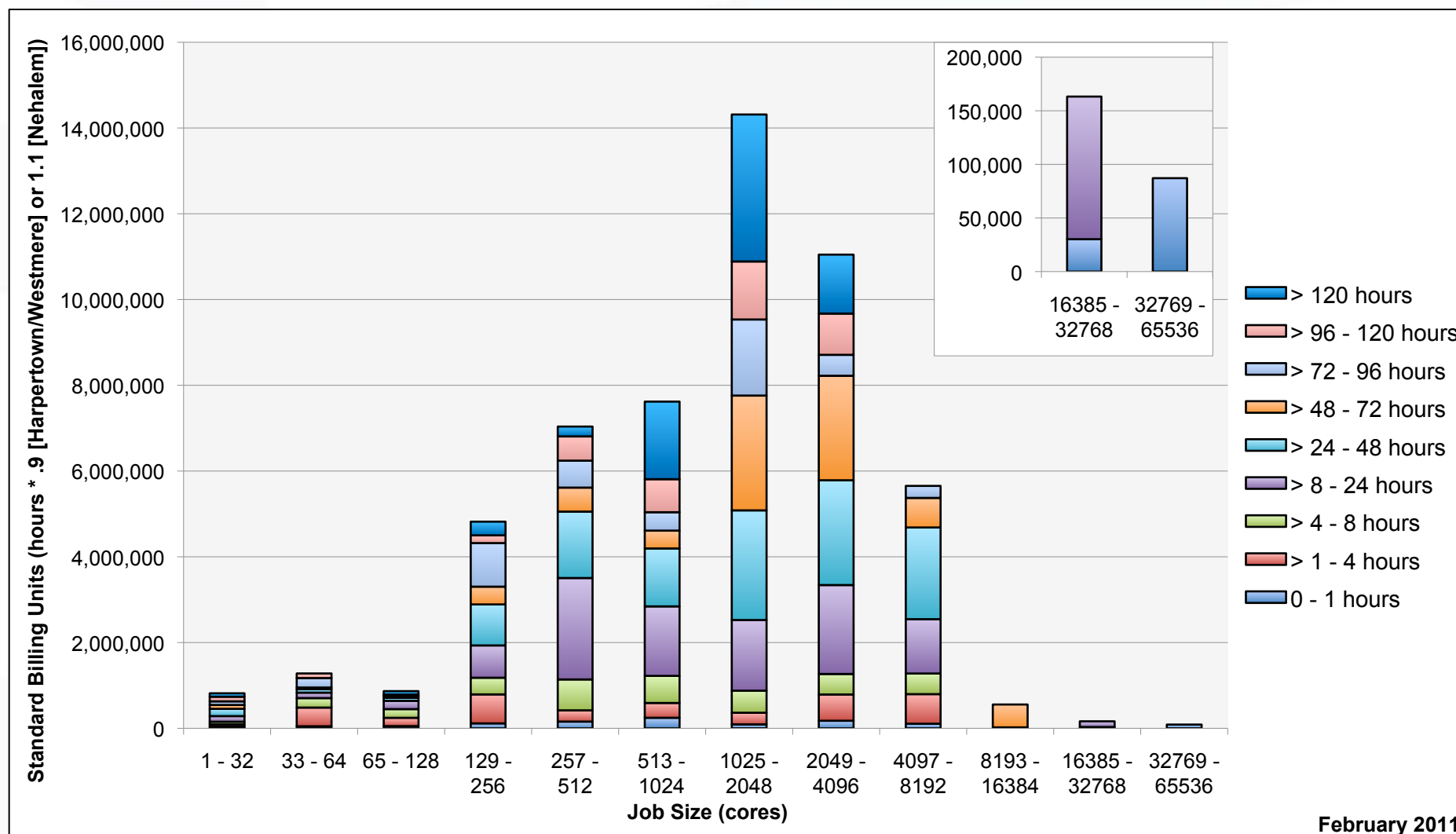


Pleiades: Monthly Utilization by Size and Mission



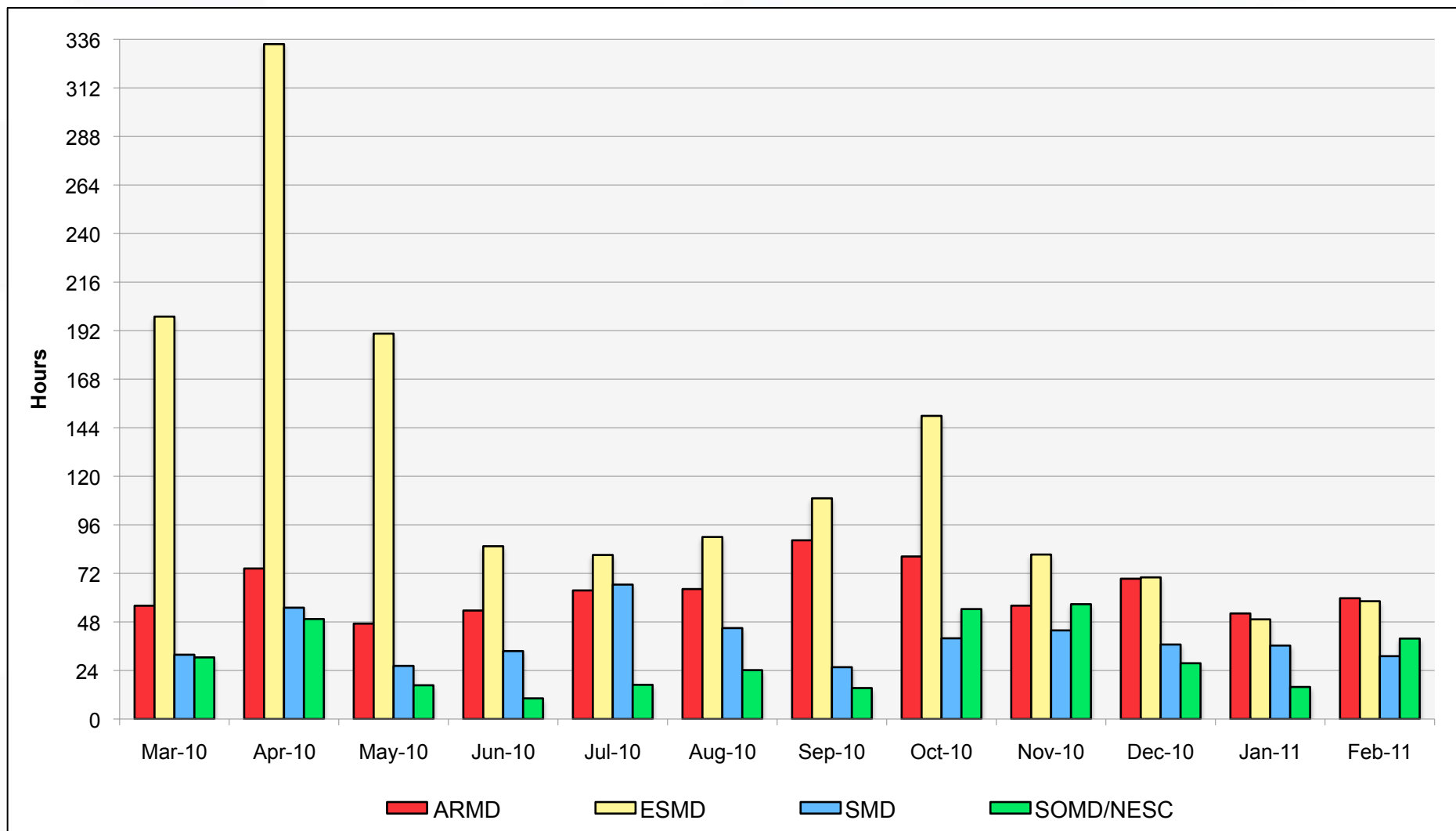


Pleiades: Monthly Utilization by Size and Length



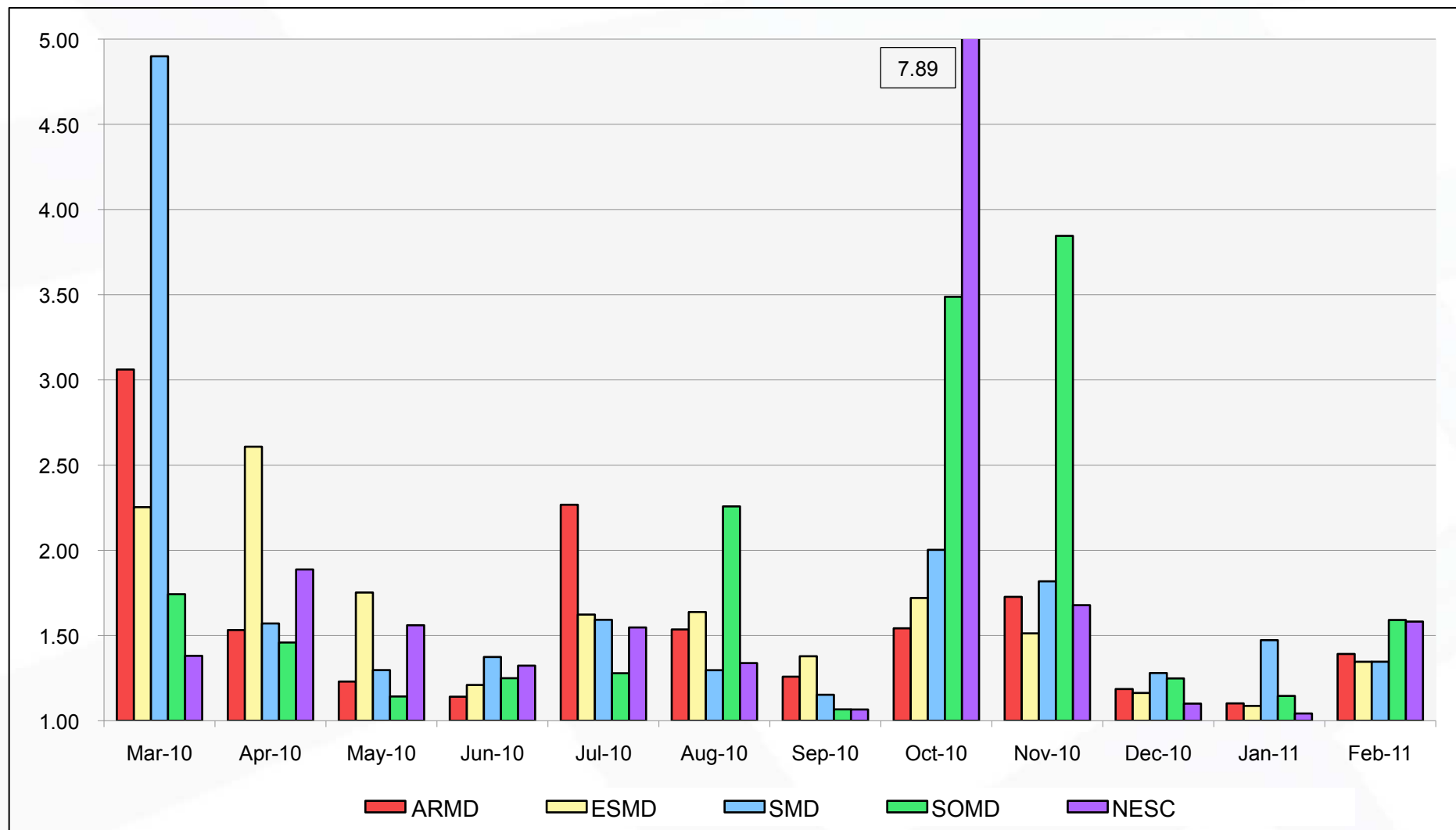


Pleiades: Average Time to Clear All Jobs

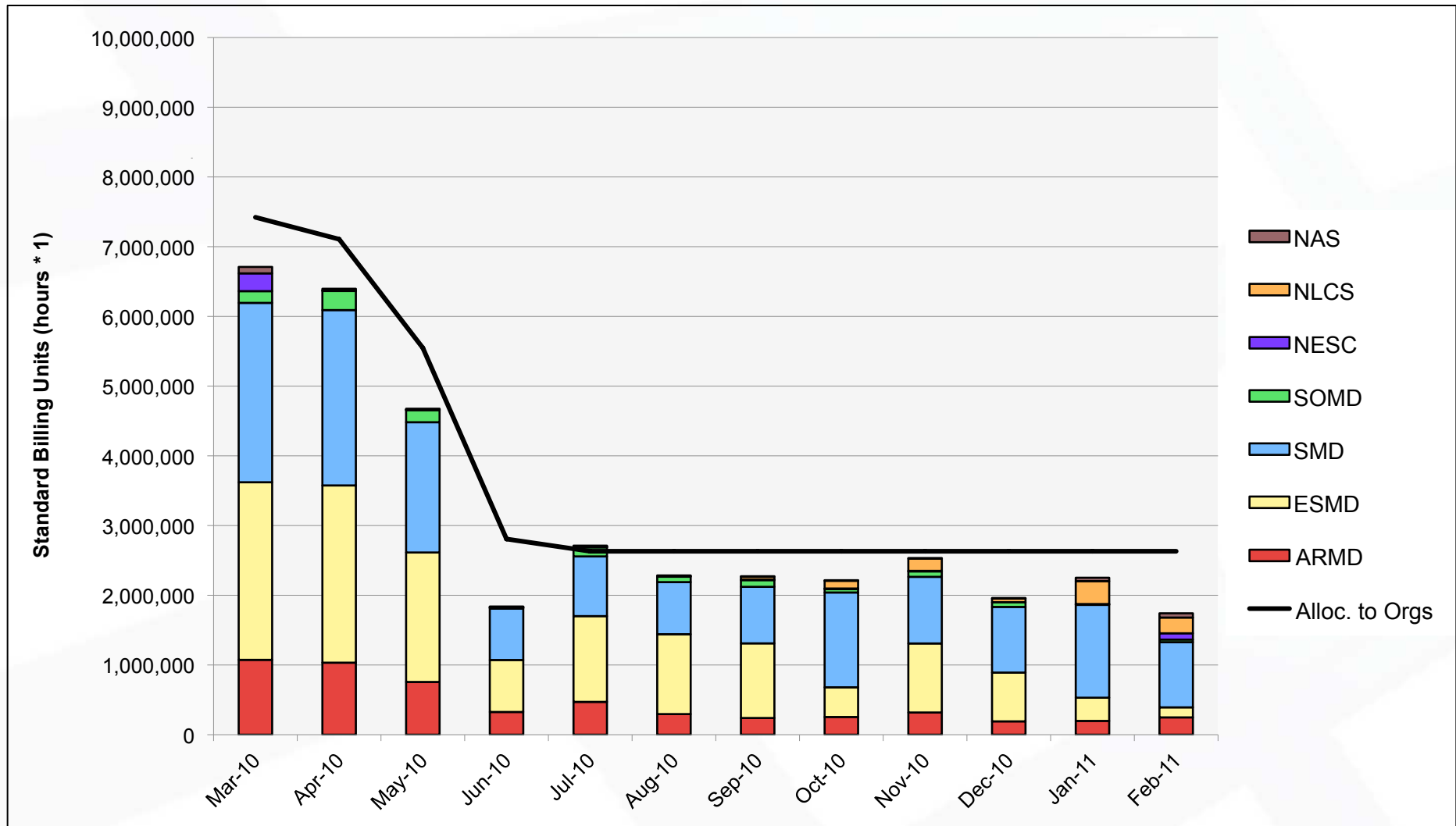
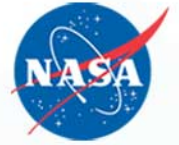




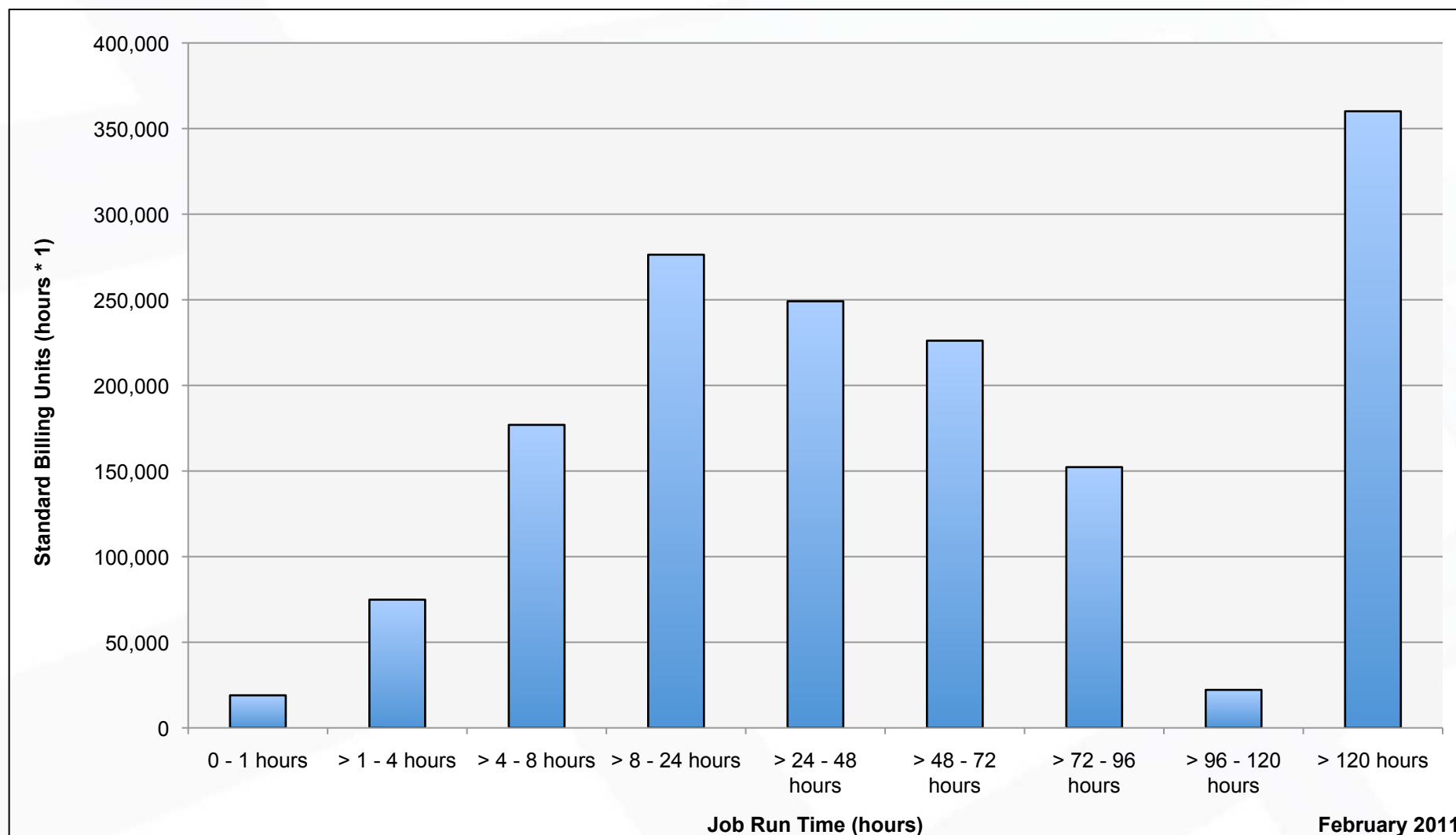
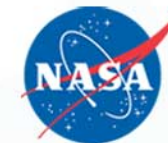
Pleiades: Average Expansion Factor



Columbia: SBUs Reported, Normalized to 30-Day Month

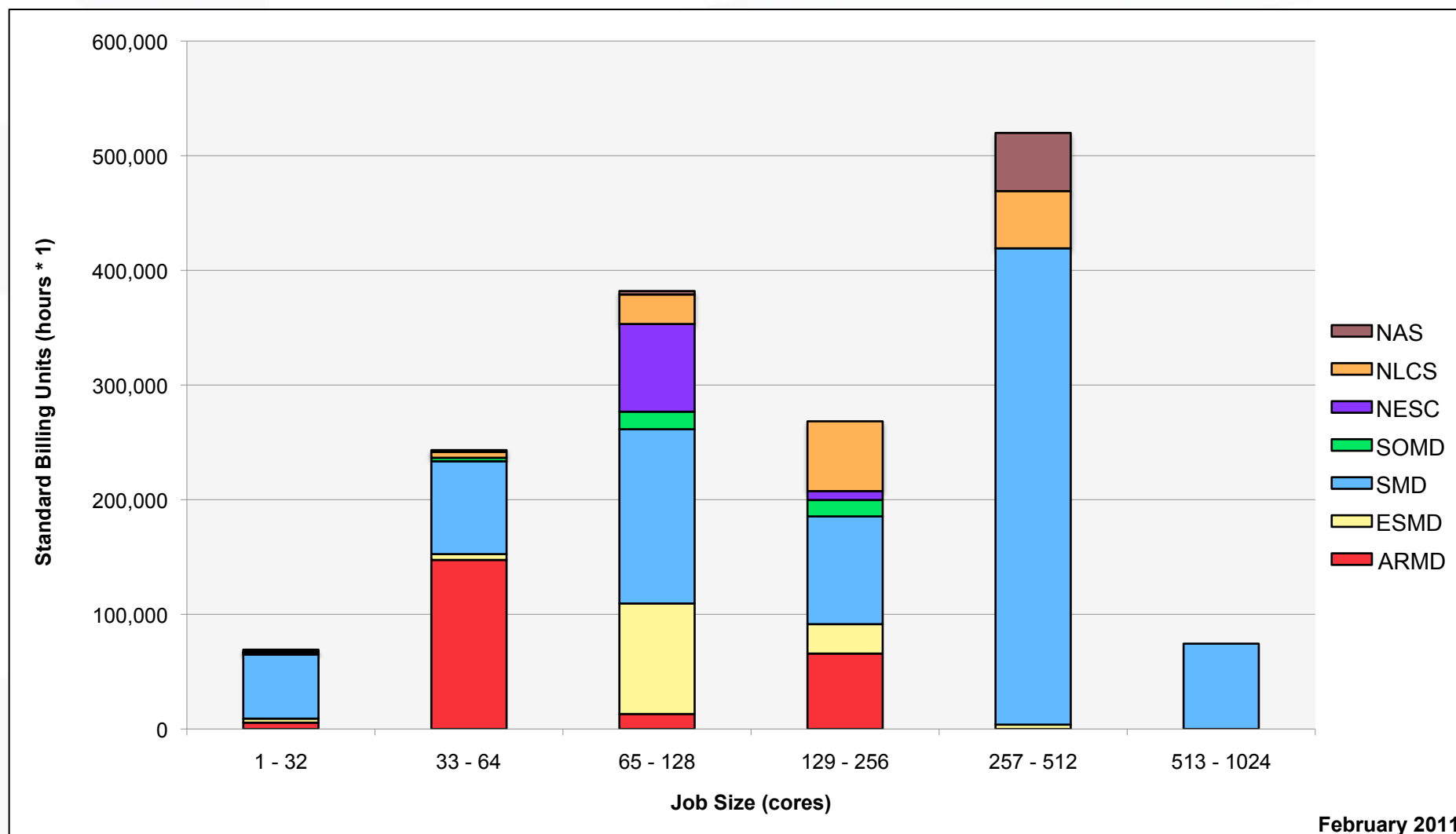


Columbia: Monthly SBUs by Run Time



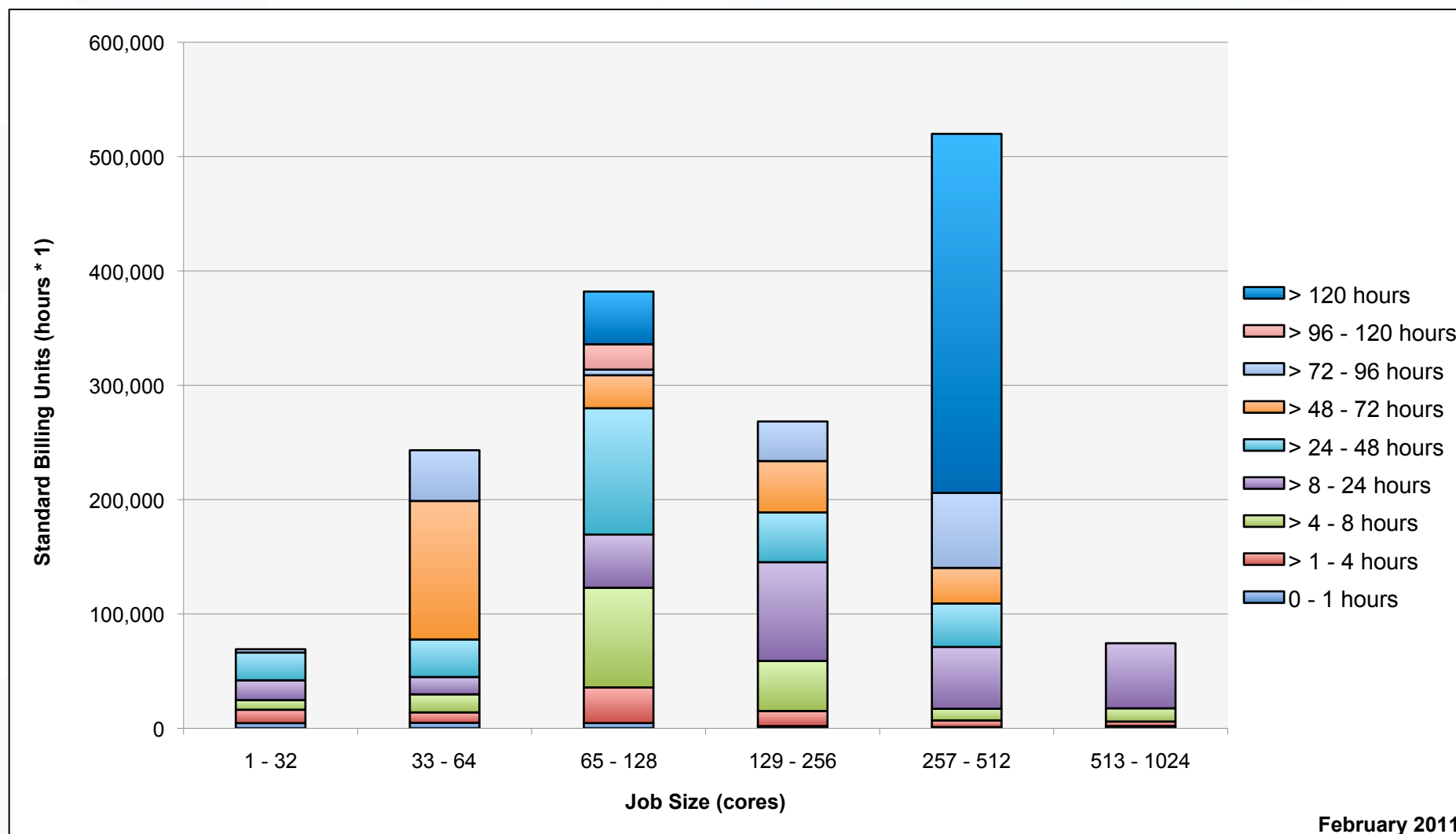


Columbia: Monthly Utilization by Size and Mission

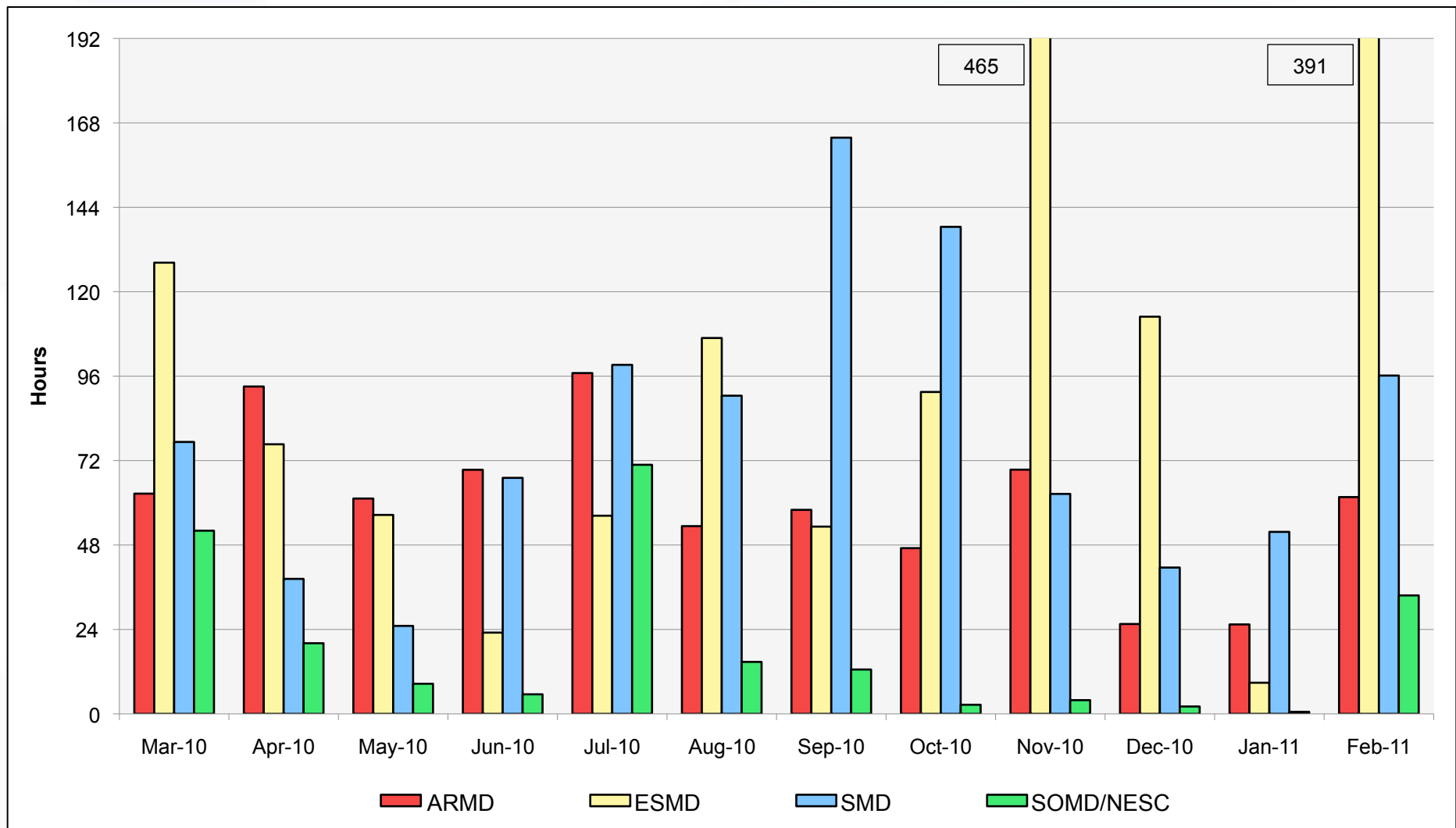




Columbia: Monthly Utilization by Size and Length



Columbia: Average Time to Clear All Jobs



Columbia: Average Expansion Factor

